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CITY OF MONROE

TECHNICAL MEMORANDUM

TO: Tom Giese, PE, BHC Consultants, LLC

FROM: Amy Power, PE, and Steven R. Wright, PE

DATE: June 6, 2023

RE: **Summary of Geotechnical Engineering Services**
City of Monroe Wastewater Treatment Plant Biosolids Facility
Investment Grade Audit Design
Monroe, Washington
Project No. 1073043.010.011

INTRODUCTION

This memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (Landau) in support of the City of Monroe Wastewater Treatment Plant Biosolids Facility Investment Grade Audit Design project in Monroe, Washington (site; Figure 1). Services were provided in accordance with the scope outlined in the Subconsultant Agreement between Landau and BHC Consultants, LLC (BHC, project civil/structural engineer), executed April 13, 2023.

This memorandum has been prepared with information provided by BHC and the City of Monroe (City, project owner).

PROJECT UNDERSTANDING

The City proposes to demolish an existing biosolids facility and replace it with a new facility. The height of the new facility will measure approximately 25 to 30 feet (ft) and it will be supported by a concrete slab-on-grade. Existing pipes and manholes will be excavated and their layout reconfigured to accommodate the new facility. The excavations are expected to extend less than 10 ft below ground surface (bgs).

In March 2010, Shannon & Wilson, Inc. advanced geotechnical explorations in support of the headworks facility, located approximately 50 ft southeast of the proposed biosolids facility. The headworks facility is constructed of concrete masonry units, which will also be used for the new biosolids facility. When preparing this memorandum, Landau reviewed the site subsurface data and geotechnical design recommendations in Shannon & Wilson's 2010 report. This report also included site subsurface data from Shannon & Wilson's 1992 and 2000 geotechnical reports that were prepared for other projects at the site.

SURFACE CONDITIONS

The site is located approximately 1,100 ft northwest of the Skykomish River and currently is developed with a wastewater treatment plant and associated infrastructure, asphalt-paved parking, and building-access areas. The site is relatively flat, with an approximately 15-ft-high retaining wall to the south.

GEOLOGIC CONDITIONS

Geologic information for the site and the surrounding area was obtained from the *Geologic Map of the Monroe 7.5-minute Quadrangle, King and Snohomish Counties, Washington* (Dragovich et al. 2011). Surficial soil at the site is mapped as alluvium (Qa) and Deltaic outwash and kame deltas (Qgod). Alluvium typically consists of gravel, sand, silt, and organic sediments, and Deltaic outwash and kame deltas (Qgod) typically consist of cobble, gravel, and sand deposits.

SUBSURFACE CONDITIONS

In March 2010, Shannon & Wilson completed a geotechnical field investigation to support expansion of the wastewater treatment plant, including construction of a headworks facility south of the Sams Street site entrance. The investigation included advancement of three hollow-stem auger borings (RW-1, RW-2, and RW-3). The approximate locations of the explorations are shown on Figure 2.

Landau reviewed summary logs of borings Shannon & Wilson advanced in March 2010; July 2000 (B-101, B-102, and B-103); and July 1992 (B-1, B-2, and B-3). Copies of the logs are included in Attachment 1. Based on Landau's review, fill and alluvium may be encountered during construction.

Alluvium was encountered in borings RW-1 and RW-2 (advanced approximately 80 ft south of the proposed biosolids facility). From ground surface to approximately 15.8 ft bgs and 19.5 ft bgs, respectively, the alluvium was in a loose to medium dense condition and consisted of sand with variable silt and gravel content. From 15.8 ft bgs (RW-1) and 19.5 ft bgs (RW-2) to the maximum depths explored (approximately 35 to 41.5 ft bgs), the alluvium was in a dense to very dense condition and consisted of gravel with variable sand and silt content.

Borings RW-1 and RW-2 were advanced before construction of the cast-in-place concrete cantilever retaining wall south of the site. Landau estimates that approximately 10 to 15 ft of fill currently overlies the alluvium encountered in these borings.

Approximately 10 ft of fill was observed over the alluvial deposits in boring RW-3 (advanced approximately 50 ft southeast of the proposed biosolids facility). The fill was in a medium dense to dense condition and consisted of gravel with variable sand and silt content or of sand with variable silt and gravel content. The alluvium beneath the fill consisted of very loose to loose sand from approximately 10 ft bgs to 23.5 ft bgs, and medium dense to very dense sandy gravel or gravelly sand from 23.5 ft bgs to the maximum depth explored (approximately 40.6 ft bgs).

Groundwater was observed at approximately 10 ft bgs in borings RW-1 and RW-2 at approximately 23.5 ft bgs in boring RW-3, and approximately 23 ft bgs in borings B-2 and B-3. (Shannon & Wilson 2010). Site groundwater conditions may vary depending on local subsurface conditions, weather conditions, and other factors. High groundwater levels or perched groundwater zones are most likely to occur in late winter and early spring.

CONCLUSIONS AND RECOMMENDATIONS

Based on Landau's review of available geotechnical information, subsurface conditions at the site are suitable for the proposed improvements, provided the following recommendations are incorporated into the project design.

Critical Areas Assessment

The site is relatively flat with a low risk of slope instability. Based on the critical area designations in Chapter 22.80 of the Monroe Municipal Code, the site is not considered an erosion or landslide hazard area.

Seismic Design Considerations

Based on the subsurface conditions encountered in Shannon & Wilson's March 2010 explorations, seismically induced soil liquefaction could occur at the site. Landau estimates that up to 3 inches of total and differential settlement could occur following a design-level earthquake. The magnitude and extent of liquefaction-induced settlement will depend on the duration and intensity of ground shaking and on local soil and groundwater conditions. The vertical distribution of soil liquefaction and the magnitude of associated settlement could differ from those estimated.

Per *2018 International Building Code* standards (ICC 2017), a site that could experience soil liquefaction should receive a Site Class F classification. If the fundamental period of the structure is less than or equal to 0.5 seconds, a Site Class D classification may be used to complete seismic design. The structural engineer should select the appropriate seismic site class based on the fundamental period of the proposed structure. If the fundamental period is greater than 0.5 seconds, a site response analysis would be required. (Note that Landau's authorized scope of services does not include a site response analysis.)

Given the distance between the site and the nearest known active crustal fault, the risk of ground rupture due to surface faulting is low. Given the distance between the site and the nearest known free face (the bank of the Skykomish River, located approximately 1,100 ft southeast of the site), the risk of lateral spreading is low.

Foundation Support

The parameters in Table 1 can be used to design shallow foundations. The parameters should be used in conjunction with the complete recommendations in this memorandum.

Table 1. Summary of Design Parameters for Shallow Foundations

Allowable soil bearing pressure = 3,000 psf[a]

Allowable coefficient of sliding resistance = 0.35
Allowable passive earth pressure = 260 pcf
Minimum foundation width = 16 inches (continuous), 24 inches (isolated)
Maximum foundation width (for settlement considerations) = 10 ft (continuous), 15 ft (isolated)

(a) Allowable soil bearing pressure for footings established on at least 12 inches of imported structural fill supported by medium dense fill or alluvium or established on structural fill that extends to such soils.
ft = feet
pcf = pounds per cubic foot
psf = pounds per square foot

When calculating the allowable soil bearing pressure, Landau assumed that shallow foundations would be established on at least 12 inches of imported structural fill supported by medium dense fill or alluvium or on structural fill that extends to such soils. Unsuitable soils should be overexcavated and replaced with properly compacted structural fill, as described in the Earthwork and Construction Considerations section herein. The geotechnical engineer should evaluate foundation subgrades prior to placement of formwork, rebar, or structural fill.

The allowable soil bearing pressure in Table 1 applies to dead and live loads, exclusive of the weight of the footing and any overlying backfill. The bearing pressure includes a factor of safety of at least 2.0 on the calculated ultimate bearing capacity. The bearing pressure can be increased by one-third for transient loads, such as those induced by wind and seismic forces.

For frost protection, Landau recommends embedding perimeter footings at least 12 inches below the lowest adjacent grade, where the ground is flat. Interior footings should be embedded at least 6 inches below the nearest adjacent grade. Landau estimates that footings or slabs-on-grade will settle less than 1 inch if constructed as recommended herein. Similarly loaded foundation elements will likely experience ½ inch or less of differential settlement over 25-ft spans. Settlement is expected to occur as loads are applied during construction.

An allowable coefficient of sliding resistance of 0.35, applied to vertical dead loads only, can be used to compute frictional resistance acting on the base of footings. This coefficient includes a factor of safety of 1.5 on the calculated ultimate value.

The passive resistance of properly compacted structural fill placed against the sides of foundations can be considered equivalent to a fluid with a density of 260 pounds per cubic foot. The foundation passive earth pressure has been reduced by a factor of 1.5 to limit deflections to less than 2 percent of the embedded depth. The passive earth pressure and friction components can be combined, provided the passive component does not exceed two-thirds of the total. The top 1 ft of soil should be excluded from the calculation unless the foundation perimeter will be covered by a slab-on-grade or pavement.

Slabs-On-Grade

Slabs-on-grade should be installed on at least 6 inches of structural fill placed on a uniformly firm, unyielding subgrade. A modulus of vertical subgrade reaction (subgrade modulus) can be used to design slabs-on-grade. The subgrade modulus will vary based on the dimensions of the slab and the magnitude of applied loads on the slab surface; slabs with larger dimensions and loads are influenced by soils to a greater depth. Landau recommends using a subgrade modulus of 160 pounds per cubic inch to design on-grade floor slabs. This subgrade modulus is for a 1-ft-by-1-ft square plate and is not the overall modulus of a larger area.

Interior slabs-on-grade should include a vapor barrier and a capillary break layer, designed and installed in accordance with industry standards.

EARTHWORK AND CONSTRUCTION CONSIDERATIONS

The following key points should be considered when developing project plans and specifications:

- **Site preparation:** Site preparation activities are expected to include demolition and removal of existing structures and asphalt pavement. Topsoil and construction debris should be stripped from all areas designated for development (i.e., footings and slabs-on-grade). Topsoil is not suitable for reuse as structural fill but can be stockpiled and used in landscaped areas.
- **Subgrade preparation:** Before structural fill, formwork, or pavement base course is placed, the subgrade should be scarified, moisture-conditioned, and compacted to a firm, unyielding condition. The prepared subgrade should be proof-rolled in the presence of a qualified geotechnical engineer, who is familiar with the site and can check for loose/disturbed areas. Areas of limited access can be evaluated with a steel T-probe. If probing or proof-rolling reveals loose and/or disturbed subgrades, additional moisture conditioning and compaction should be completed to produce a firm, unyielding condition. Alternatively, unsuitable soils can be overexcavated and replaced with properly compacted structural fill.
- **Footing overexcavations:** Landau does not anticipate the need for appreciable foundation footing overexcavations. Landau recommends that the construction budget includes a small contingency for local overexcavation of unsuitable fill.

  If overexcavations are required, the overexcavation zone should extend beyond the side of each footing a horizontal distance that is equal to at least one-half of the overexcavation depth. For example, a 2-ft-wide footing with a 2-ft-deep overexcavation should have a 4-ft-wide overexcavation zone. All footing overexcavations should be backfilled with structural fill and compacted to at least 95 percent of the maximum dry density. The base of the overexcavation should be evaluated by a qualified civil or geotechnical engineer prior to placement of structural fill.
- **Utility trench excavation and backfill:** Landau anticipates that utility trenches will be excavated in loose to medium dense, sand with variable silt and gravel content. A heavy-duty excavator should be able to reach the required trench depths (up to 10 ft bgs). A smooth-bladed bucket should be used to remove loose and/or disturbed soil from the trench bottom. The final trench bottom should be firm and free of roots, topsoil, lumps of silt and clay, construction debris, and organic and inorganic debris.
- **Reuse of site soil:** Site soils are generally moisture sensitive and should not be reused as structural fill.
- **Structural fill:** Structural fill may include Gravel Borrow that conforms to the requirements in Section 9-03.14(1) of the Washington State Department of Transportation’s 2023 *Standard Specifications for Road, Bridge, and Municipal Development* (hereafter, *2023 WSDOT Standard*

Specifications). During periods of wet weather, the fines content should not exceed 5 percent, based on the minus ¾-inch fraction. Structural fill should be used as backfill within the limits of the structural excavation.

- **Fill placement and compaction:** Structural fill should be placed on an approved subgrade that consists of uniformly firm, unyielding, inorganic native soils or of compacted structural fill that extends to such soils. Structural fill should be placed and compacted in accordance with the requirements in Section 2-03.3(14)C, Method C of the *2023 WSDOT Standard Specifications.* Method A is appropriate for non-structural areas, such as landscaping. Each layer of structural fill should be compacted to at least 95 percent of the maximum dry density, determined in accordance with the compaction control tests in Section 2-03.3(14)D of the *2023 WSDOT Standard Specifications.*
- **Temporary excavations:** Temporary excavations should be completed in accordance with the requirements in Section 2-09 of the *2023 WSDOT Standard Specifications.* The contractor should be responsible for determining actual excavation configurations and maintaining safe working conditions, including temporary excavation stability. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements in Safety Standards for Construction Work, Part N (Washington State Department of Labor and Industries, Chapter 296-155 of the Washington Administrative Code). All applicable local, state, and federal safety codes should be followed. Type C soils with a maximum allowable excavation inclination of 1.5 horizontal to 1 vertical are likely to be exposed in the excavation sidewalls.
- **Temporary Construction dewatering:** During Shannon & Wilson's March 2010 field investigation, groundwater was observed at approximately 23.5 ft bgs in boring RW-3, and approximately 10 ft bgs in borings RW-1 and RW-2 (note that borings RW-1 and RW-2 were advanced prior to construction of the existing cantilever wall). Temporary excavations should be dewatered to allow construction to be completed in the dry. Where shallow groundwater seepage is encountered, the use of conventional sumps and pumps should be sufficient to dewater excavations. The contractor should be responsible for the design, monitoring, and maintenance of any dewatering systems.

CONSTRUCTION MONITORING

Monitoring, testing, and consultation should be provided during construction to confirm that site conditions are consistent with those observed in Landau's explorations and to provide expedient recommendations should conditions differ from those anticipated. Monitoring will also allow Landau to evaluate construction activities for compliance with the project plans and specifications and the recommendations herein. Activities may include evaluation of fill material; compaction testing of structural fill; and preparation of slab, pavement, and structural foundation subgrades. Landau would be pleased to provide construction monitoring services.

USE OF THIS TECHNICAL MEMORANDUM

Landau Associates has prepared this technical memorandum for the exclusive use of BHC Consultants, LLC; the City of Monroe; and their designated representatives for specific application to the City of Monroe Wastewater Treatment Plant Biosolids Facility Investment Grade Audit Design project in Monroe, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Reuse of the information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that, within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of skill and care ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

CLOSING

We trust that this memorandum provides you with the information needed to proceed with the project. If you have questions or comments, or if we can be of further service, please contact Amy Power at 253.284.4882 or at apower@landauinc.com.

LANDAU ASSOCIATES, INC.

Amy Power, PE
Senior Project Engineer

Steven R. Wright, PE
Principal

6-6-2023

ALP/SZW/tmh/mcs
[\\TACOMA3\PROJECT\1073\043.010\R\FINAL\CITY OF MONROE WWTP BIOSOLIDS FACILITY IGA DESIGNTECHNICAL MEMORANDUM_6.06.2023.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site and Exploration Plan
Attachment 1. Historical Boring logs

REFERENCES

City of Monroe. Monroe Municipal Code. Chapter 22.80. Critical Areas. Current through Ordinance 001/2020, passed January 24, 2023.

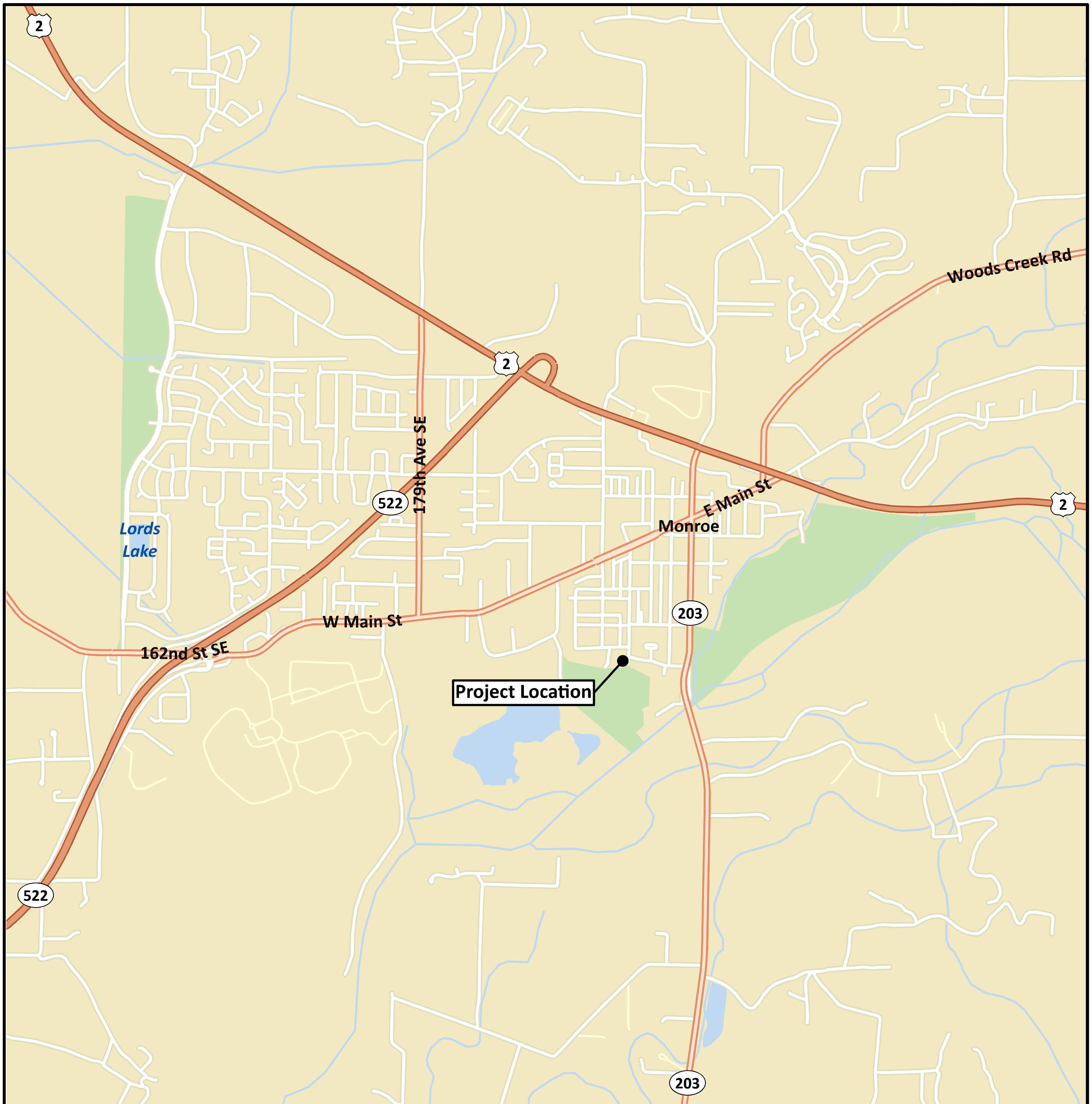
Dragovich, J.D., M.L. Anderson, S.A. Mahan, C.J. Koger, J.H. Saltonstall, J.H. MacDonald, et al. 2011. *Geologic Map of the Monroe 7.5-minute Quadrangle, King and Snohomish Counties, Washington.* Washington Department of Natural Resources, Washington Division of Geology and Earth Resources.

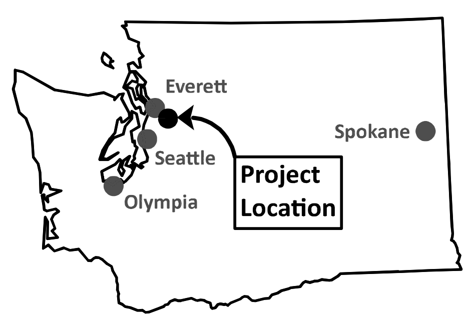
ICC. 2017. *2018 International Building Code.* International Code Council.

LNI. 2020. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries.

Shannon & Wilson, Inc. 2010. Geotechnical Report: Monroe Wastewater Treatment Plan, Phase III Improvements, Monroe, Washington. June 4.

WSDOT. 2022. *M41-10: Standard Specifications for Road, Bridge, and Municipal Construction.* 2023 Edition. Washington State Department of Transportation.





Data Source: Esri.

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LANDAU ASSOCIATES

City of Monroe Wastewater Treatment Plant Biosolids Facility IGA Design Monroe, Washington	**Vicinity Map**	Figure 1

<u>Legend</u>

RW-1 ◐ Approximate Soil Boring Location and Designation (Shannon & Wilson 2010)

B-2 ⊕ Approximate Soil Boring Location and Designation (Shannon & Wilson 1992)

▭ Approximate Project Area

<u>Note</u>

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 40 80

Scale in Feet

Data Source: Snohomish County GIS.

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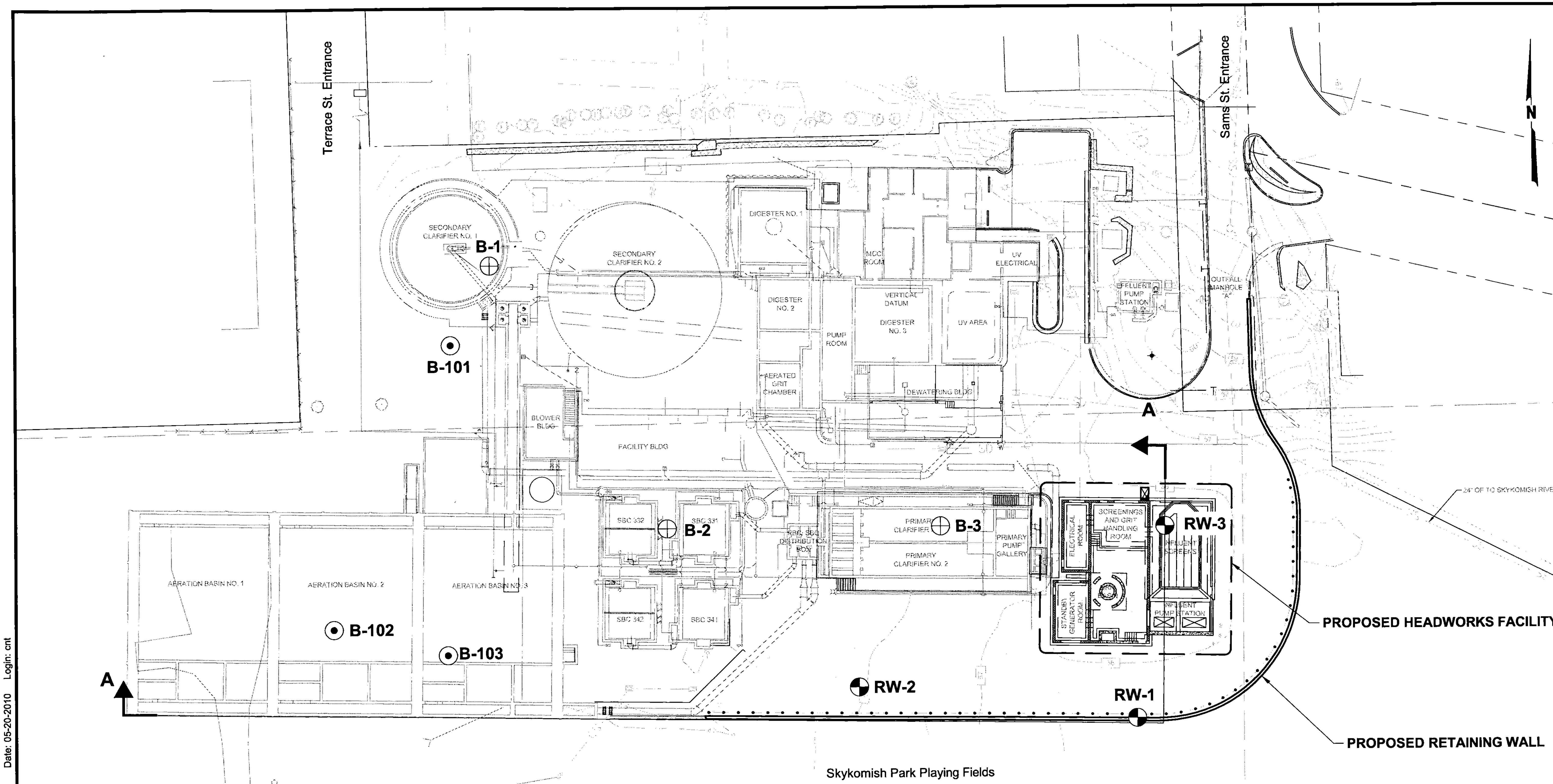
LANDAU ASSOCIATES

City of Monroe Wastewater Treatment Plant Biosolids Facility IGA Design Monroe, Washington	**Site and Exploration Plan**	Figure 2

ATTACHMENT 1

Historical Boring Logs



NOTE

RW-1 — Boring Designation and Approximate Location (Current)

B-101 — Boring Designation and Approximate Location (2000)

B-1 — Boring Designation and Approximate Location (1992)

A — Generalized Subsurface Profile Designation and Approximate Location (See Figure 3)

0 40 80

Scale in Feet

NOTE

Figure adapted from electronic files provided by Carollo Engineering, received 5-6-2010.

City of Monroe
Monroe WWTP Phase III Improvements
Monroe, Washington

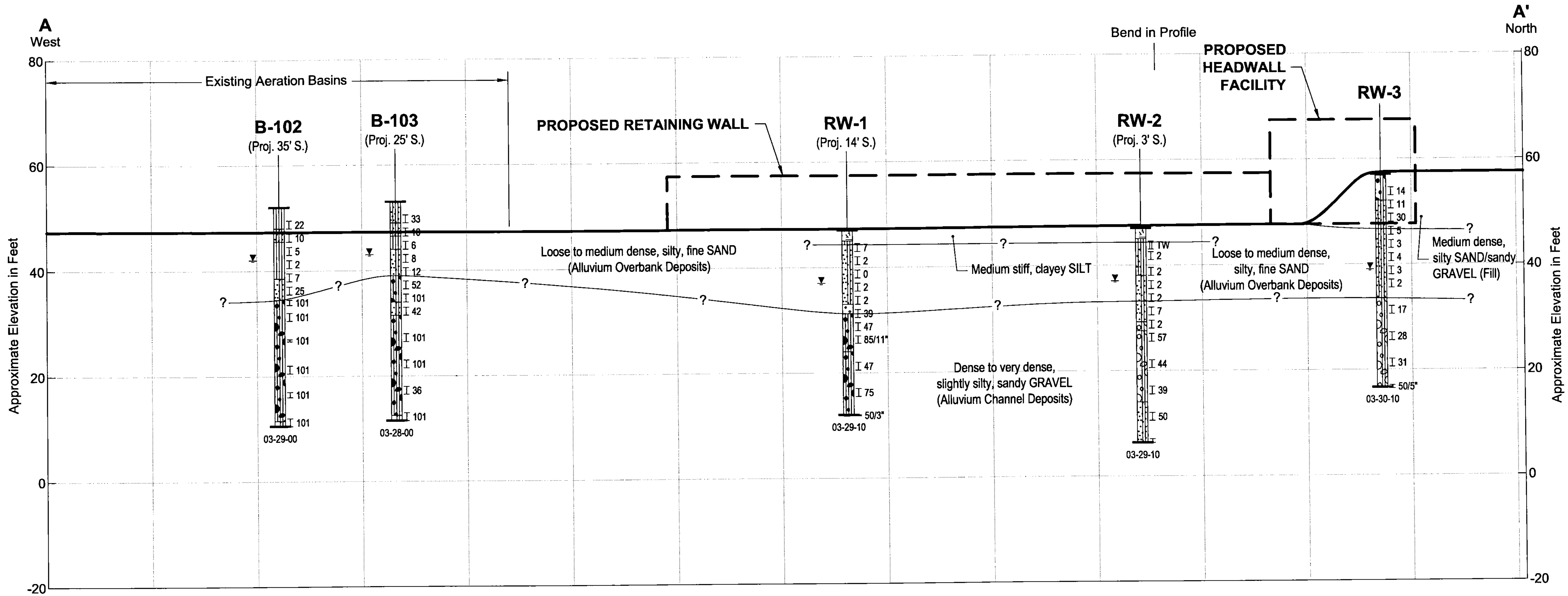
SITE AND EXPLORATION PLAN

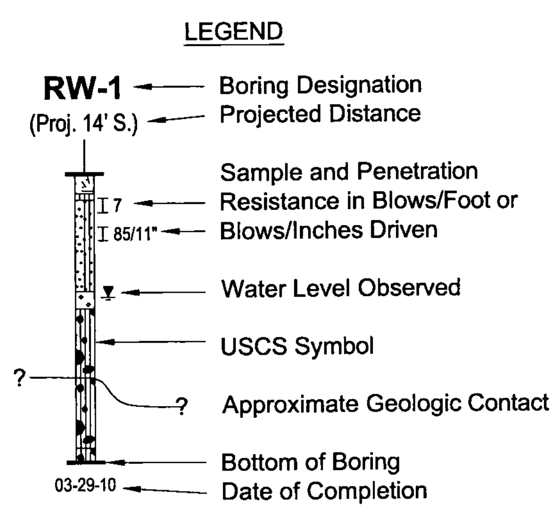
May 2010 21-1-21237-003

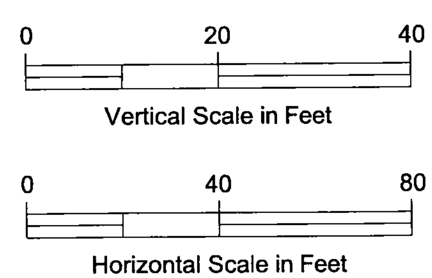
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

Filename: J:\211\21237-003\21-1-21237-003 Fig 2.dwg Date: 05-20-2010 Login: cnt







Vertical Exaggeration = 2X

NOTE

This subsurface profile is generalized from materials observed in soil borings. Variations may exist between profile and actual conditions.

City of Monroe
Monroe WWTP Phase III Improvements
Monroe, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

May 2010 | 21-1-21237-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3

Filename: J:\211\21237-003\21-1-21237-003 Fig 3.dwg Date: 05-20-2010 Login: cnt

Total Depth:	35 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	~ 47 ft.	Easting:		Drilling Company:	Gregory	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	CME 306 Track Rig	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

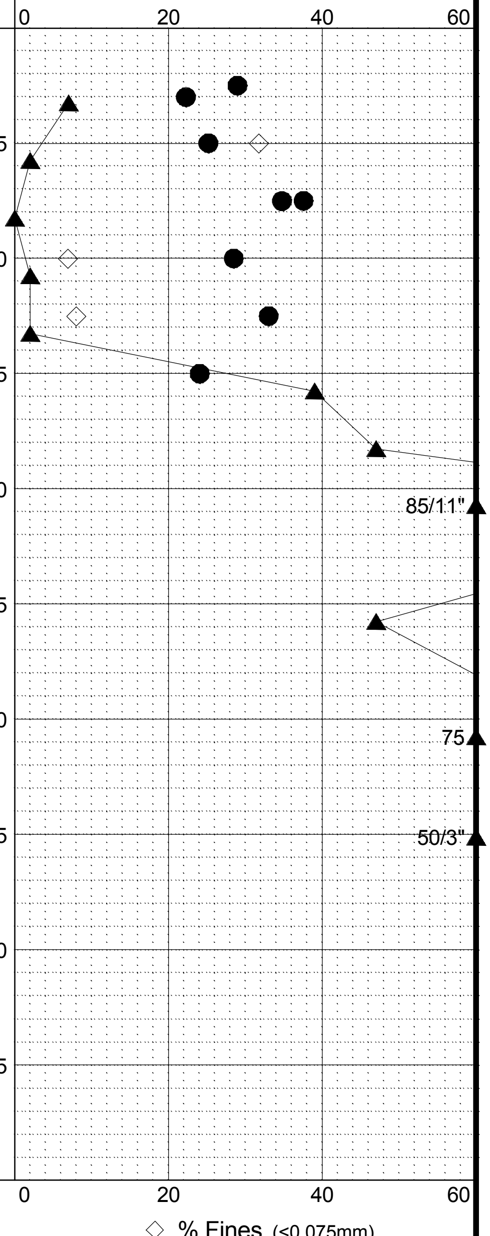
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
TOPSOIL.	2.0		
Medium stiff, gray-blue/gray, clayey SILT; moist; organic matter; ML/MH (Alluvium overbank deposits).	2.7	1	
Very loose to loose, brown, slightly silty to silty, fine to medium SAND, grading to slightly silty, gravelly SAND; occasional silt seams; moist to wet; iron-oxide stains from 10.9 to 11.2 feet; SP-SM/SM (Alluvium overbank deposits).	14.0	2, 3, 4, 5	During Drilling
Medium dense, brown, slightly gravelly SAND; wet; SW (Alluvium channel deposits).	15.8	6	
Dense to very dense, brown, silty, sandy GRAVEL; wet; GM (Alluvium channel deposits).	23.0	7, 8	
Dense to very dense, brown-orange, silty, sandy GRAVEL; wet; occasional clayey silt pockets at 25.0 feet; GM (Alluvium channel deposits).	35.2	9, 10, 11*	

BOTTOM OF BORING
COMPLETED 3/29/10

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered
Standard Penetration Test
Ground Water Level ATD

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

City of Monroe
Monroe WWTP Phase III Improvements
Monroe, Washington

LOG OF BORING RW-1

May 2010 21-1-21237-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2

REV 2

Total Depth:	40.7 ft.	Northing:		Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation:	~ 47 ft.	Easting:		Drilling Company:	Gregory	Rod Diam.:	
Vert. Datum:		Station:		Drill Rig Equipment:	CME 306 Track Rig	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

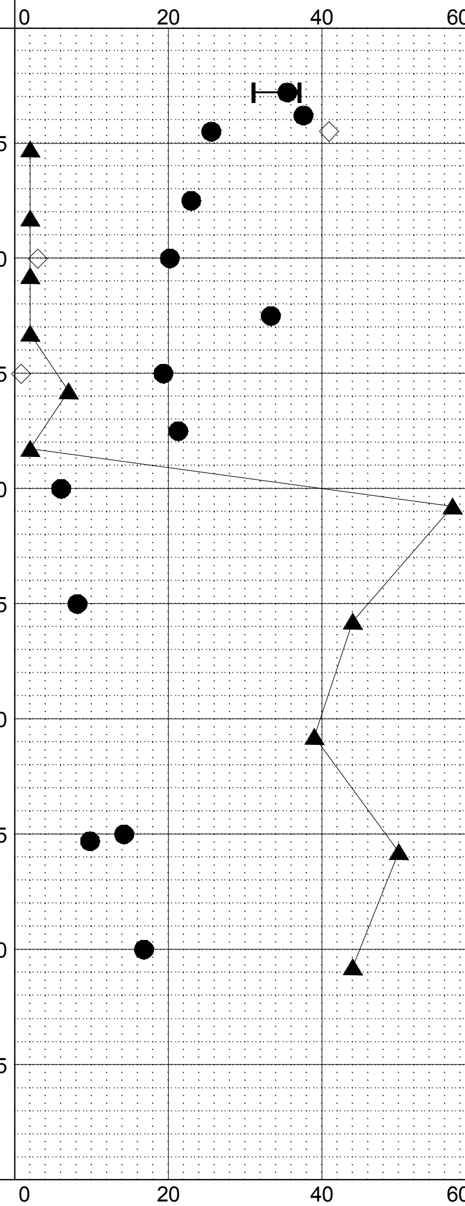
Soil Description	Depth, ft.	Samples
TOPSOIL.	2.0	
Medium stiff, gray-blue, clayey SILT; moist; ML/MH (Alluvium overbank deposits).	2.7	1
Very loose, gray-brown mottled, silty fine SAND/fine sandy SILT grading to brown, slightly silty, fine to medium SAND; SM/ML (Alluvium overbank deposits).	9.0	2, 3
Very loose to loose, brown to gray, trace to slightly silty, gravelly SAND; wet; medium sand lenses and roots at 12.5 feet; SP/SP-SM (Alluvium channel deposits).	17.8	4, 5, 6
Very loose, gray, slightly silty, sandy GRAVEL; wet; GP-GM (Alluvium channel deposits).	19.5	7
Dense to very dense, brown-gray and orange, slightly silty, sandy GRAVEL; moist to wet; GP-GM (Alluvium channel deposits).	33.0	8, 9, 10
Dense to very dense, gray-brown, slightly silty, gravelly SAND; moist to wet; SP-SM (Alluvium channel deposits).	41.5	11, 12

Ground Water: During Drilling ▽

BOTTOM OF BORING
COMPLETED 3/29/2010

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered
Thin Wall Sample
Standard Penetration Test
▽ Ground Water Level ATD

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

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4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

City of Monroe
Monroe WWTP Phase III Improvements
Monroe, Washington

LOG OF BORING RW-2

May 2010 21-1-21237-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3

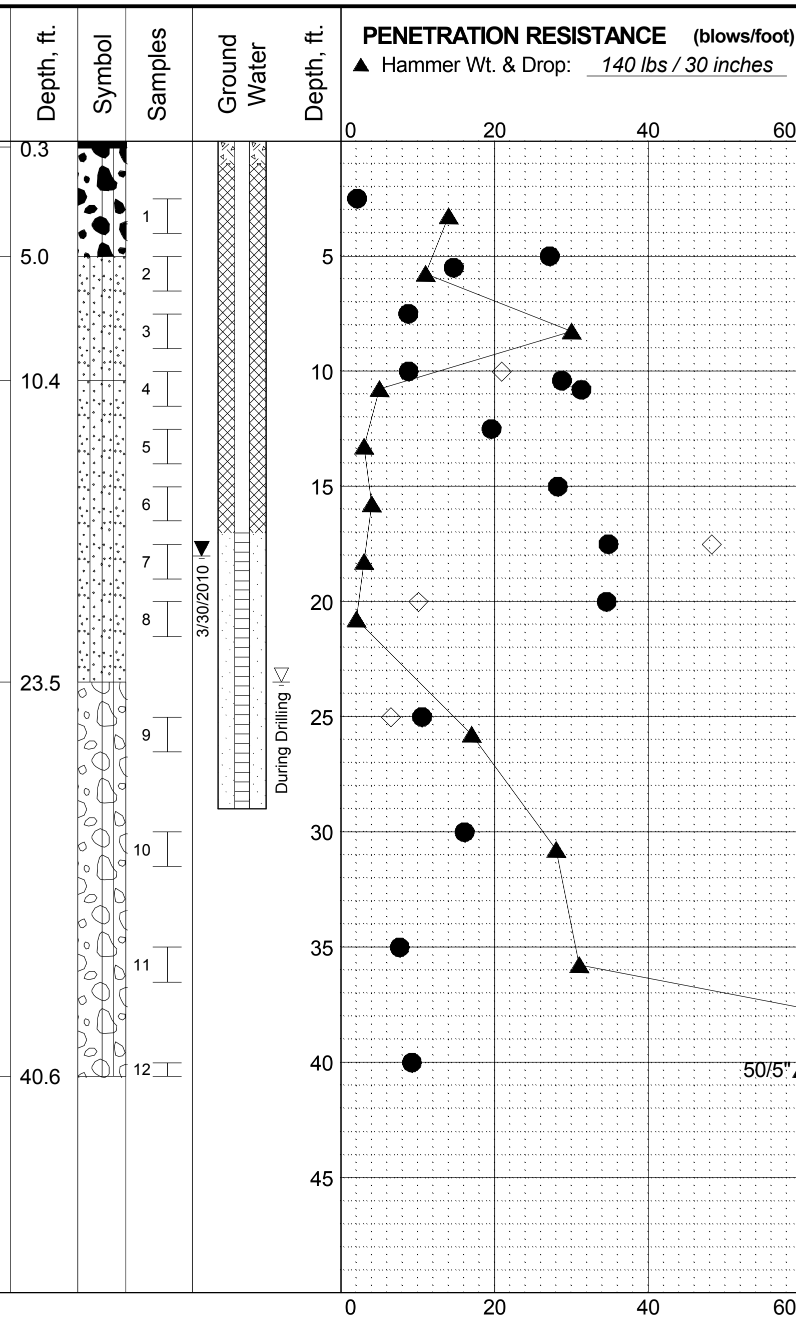
REV 2

Total Depth: 40.4 ft.	Northing:	Drilling Method:	Hollow Stem Auger	Hole Diam.:	6 in.
Top Elevation: ~ 57 ft.	Easting:	Drilling Company:	Gregory	Rod Diam.:	
Vert. Datum:	Station:	Drill Rig Equipment:	CME 306 Track Rig	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
ASPHALT.	0.3
Medium dense, light brown to brown, slightly silty to silty, sandy GRAVEL; moist; GW-GM (Fill).	5.0
Medium dense to dense, brown-orange, slightly gravelly, silty, fine SAND; moist; roots at 5.5 feet; SM (Fill).	10.4
Very loose to loose, brown-gray, slightly silty to silty, fine to medium SAND; moist to wet; scattered silt seams from 15.0 to 17.0 feet, medium sand pockets at 17.5 feet, scattered roots and wood debris, occasional iron-oxide stains; SM/SP-SM (Alluvium overbank deposits).	23.5
Medium dense to very dense, gray-brown, slightly silty, sandy GRAVEL/gravelly SAND; wet; scattered orange, slightly clayey, silty sand pocket at 35.0 feet; GP-GM/SP-SM (Alluvium channel deposits).	40.6
BOTTOM OF BORING COMPLETED 3/30/2010	



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations and definitions.
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5. USCS designation is based on visual-manual classification and selected lab testing.

City of Monroe
Monroe WWTP Phase III Improvements
Monroe, Washington

LOG OF BORING RW-3

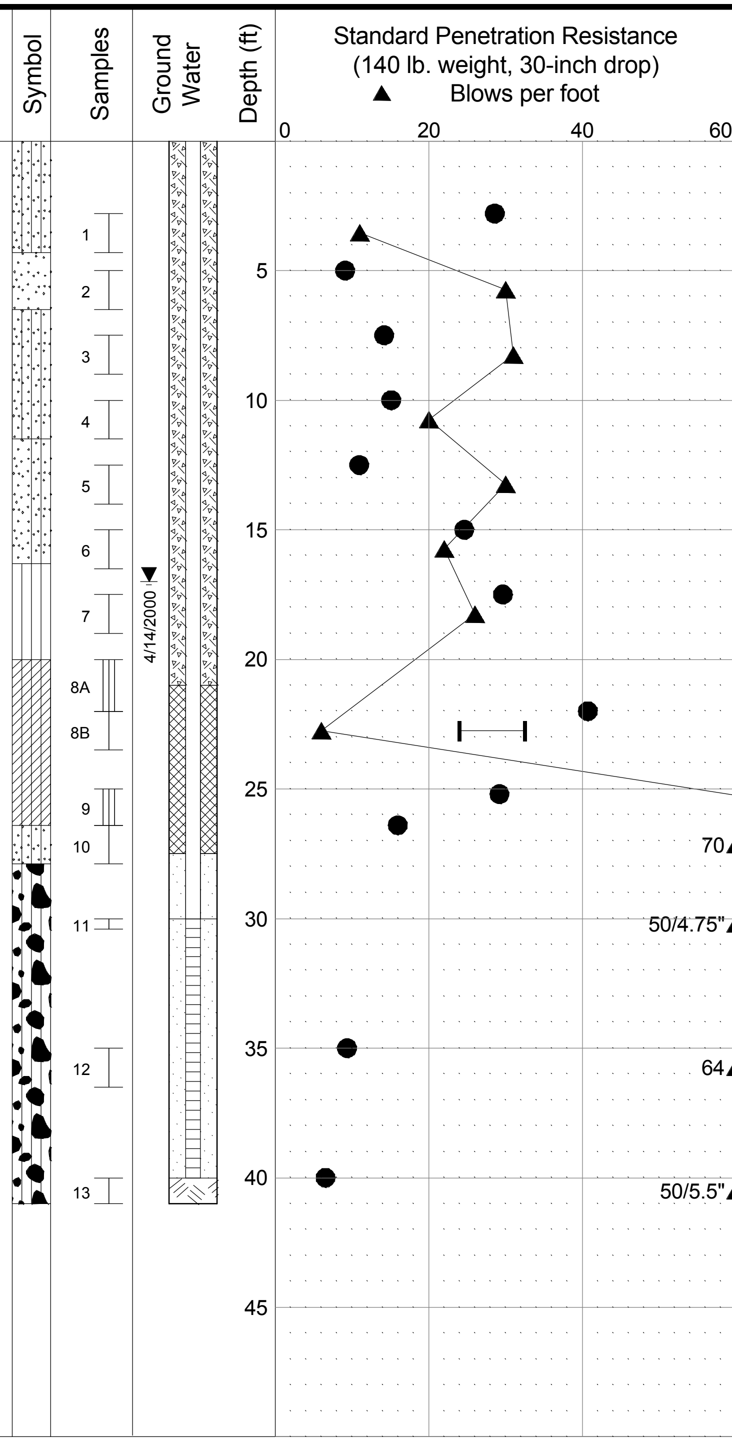
May 2010 21-1-21237-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

REV 2

SOIL DESCRIPTION Surface Elevation: Approx. 57 Ft.	Depth (ft)
Medium dense, brown, silty, fine to medium SAND, trace of gravel; moist; (Fill) SM.	4.3
Dense, brown, medium to coarse SAND, trace of gravel; moist; 3-inch layer of white, highly plastic, silty clay; (Fill) SP.	6.5
Dense, brown, silty, gravelly, fine to medium SAND; moist to wet; SM. - layer of sandy gravel from 9 to 10.5 feet - 1-inch lens of sandy silt at 11.4 feet	11.5
Medium dense to dense, brown, slightly gravelly, slightly silty, medium to coarse SAND; moist to wet; SP-SM.	16.3
Medium dense, gray, fine sandy SILT; moist to wet; ML.	20.0
Loose, gray, clayey, fine sandy SILT; moist to wet; ML/CL.	26.4
Very dense, slightly gravelly, silty, medium SAND; moist to wet; SM.	27.9
Very dense, brown and gray, silty, sandy GRAVEL; wet; GM.	41.0
BOTTOM OF BORING COMPLETED 3/29/2000	



● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

City of Monroe
Waterwater Treatment Plant Expansion
Monroe, Washington

LOG OF BORING B-101

July 2000 21-1-08965-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

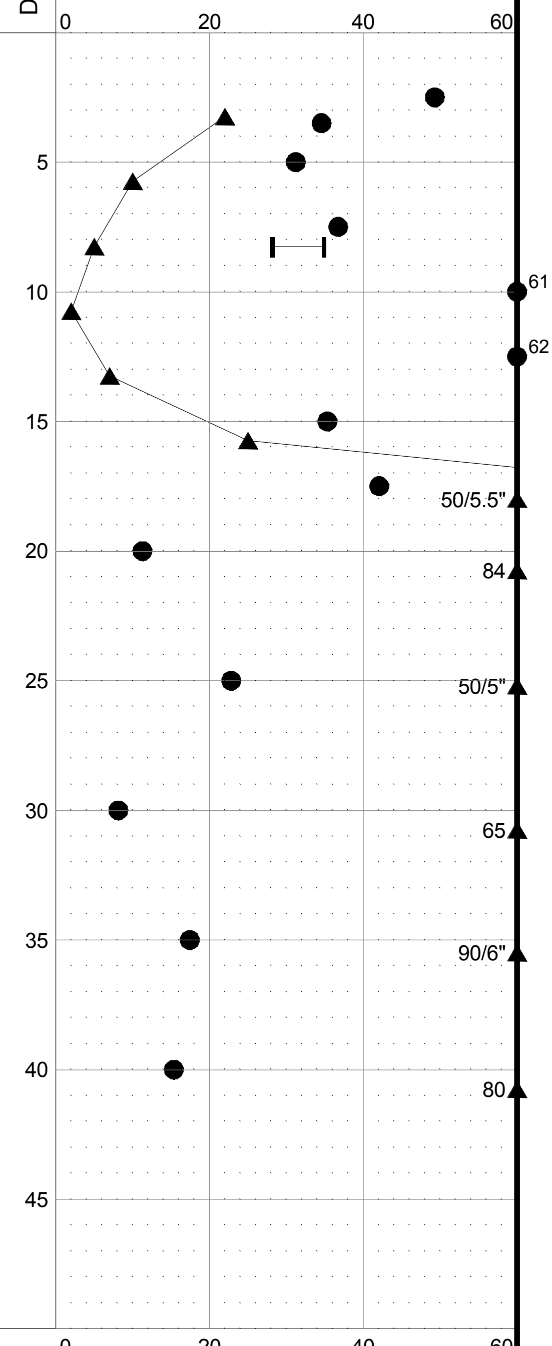
FIG. A-5

MASTER_LOG 21-08965.GPJ SHAN_WIL.GDT 5/13/10 Log: LEE Rev: Typ: PEC

SOIL DESCRIPTION Surface Elevation: Approx. 52 Ft.	Depth (ft)	Samples	Ground Water
Very stiff, gray to brown, clayey SILT; moist; occasional organics (wood fibers) and slightly organic odor; (Fill) ML-CL. - white, highly plastic, silty clay from 2.5 to 3 feet	4.0	1	
Medium dense, brown, silty, fine SAND; moist; SM.	6.5	2	
Very loose to loose, brown to gray, clayey, fine sandy SILT; moist; iron-oxide stains, occasional organics (wood fibers); ML. - wood from log from 11.5 to 13.5 feet	13.5	3, 4, 5	During Drilling
Loose to medium dense, gray, slightly silty, fine to medium SAND; moist to wet; occasional to scattered organics (wood fibers); SP-SM.	17.5	6	
Very dense, gray, silty, sandy GRAVEL; wet; GM. - wood debris from 30 to 30.4 feet	40.5	7, 8, 9, 10, 11	
Very dense, brown, slightly silty, slightly gravelly to gravelly, medium SAND; wet; SP-SM.	41.5	12	

BOTTOM OF BORING
COMPLETED 3/29/2000

Standard Penetration Resistance
(140 lb. weight, 30-inch drop)
▲ Blows per foot



● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- Ground Water Level ATD

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
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City of Monroe
Waterwater Treatment Plant Expansion
Monroe, Washington

LOG OF BORING B-102

July 2000 21-1-08965-001

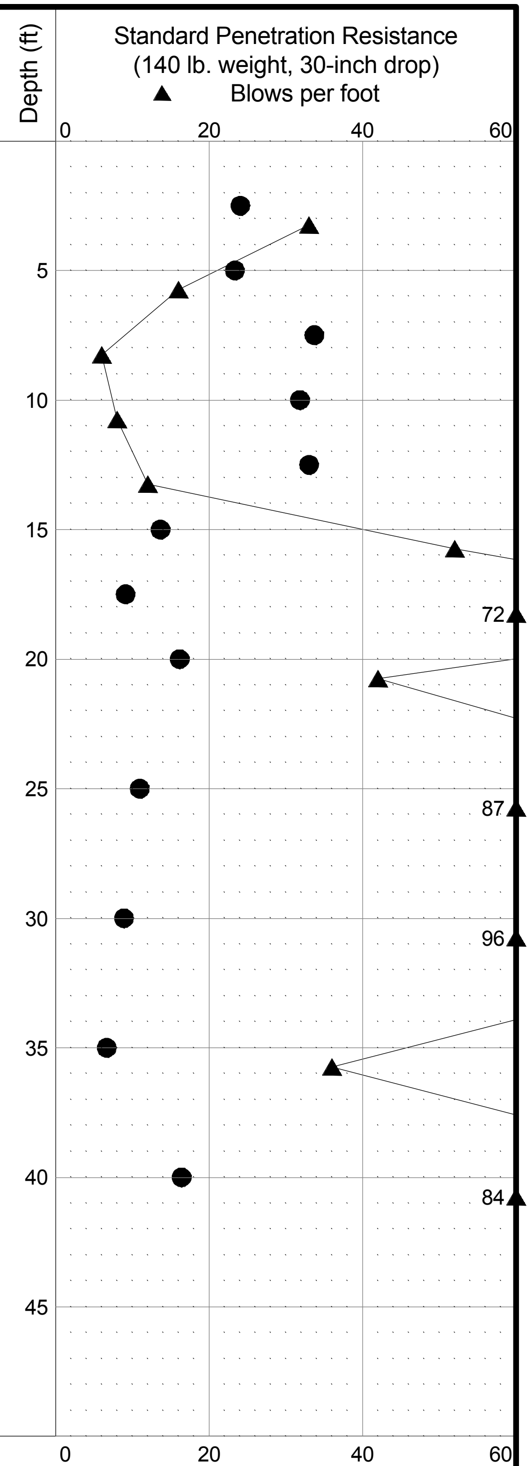
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6

MASTER LOG 21-08965.GPJ SHAN WIL.GDT 5/13/10 Log: LEE Rev: Typ: PEC

SOIL DESCRIPTION Surface Elevation: Approx. 53 Ft.	Depth (ft)	Samples	Ground Water
Dense, brown to gray, silty, gravelly, fine to medium SAND; moist; SM.	4.0	1	
Medium dense, brown , silty, fine to medium SAND; moist; 1-inch lens of gravel at 4 feet; SM.	6.5	2	
Soft, brown, slightly clayey, sandy SILT, trace of gravel; moist to wet; ML.	9.0	3	
Medium dense, brown to gray, slightly silty, fine to medium SAND, trace of gravel; moist to wet; occasional iron-oxide stains; SP-SM.	14.0	4, 5	During Drilling ▽
Very dense, gray, silty, sandy GRAVEL; wet; GM.	19.0	6, 7	
Dense, gray, slightly gravelly, slightly silty, medium to coarse SAND; moist to wet; SP-SM.	21.5	8	
Dense to very dense, brown and gray, silty, slightly sandy to sandy GRAVEL; wet; scattered iron-oxide stains; GW.	40.5	9, 10, 11	
Very dense, brown, slightly silty, slightly gravelly, medium SAND; moist; SP-SM.	41.5	12	

BOTTOM OF BORING
COMPLETED 3/28/2000



LEGEND

- * Sample Not Recovered
- 2-inch O.D. Split Spoon Sample
- 3-inch O.D. Shelby Tube Sample
- ▽ Ground Water Level ATD

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
3. Groundwater level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USCS designation is based on visual-manual classification and selected laboratory index testing.

City of Monroe
Waterwater Treatment Plant Expansion
Monroe, Washington

LOG OF BORING B-103

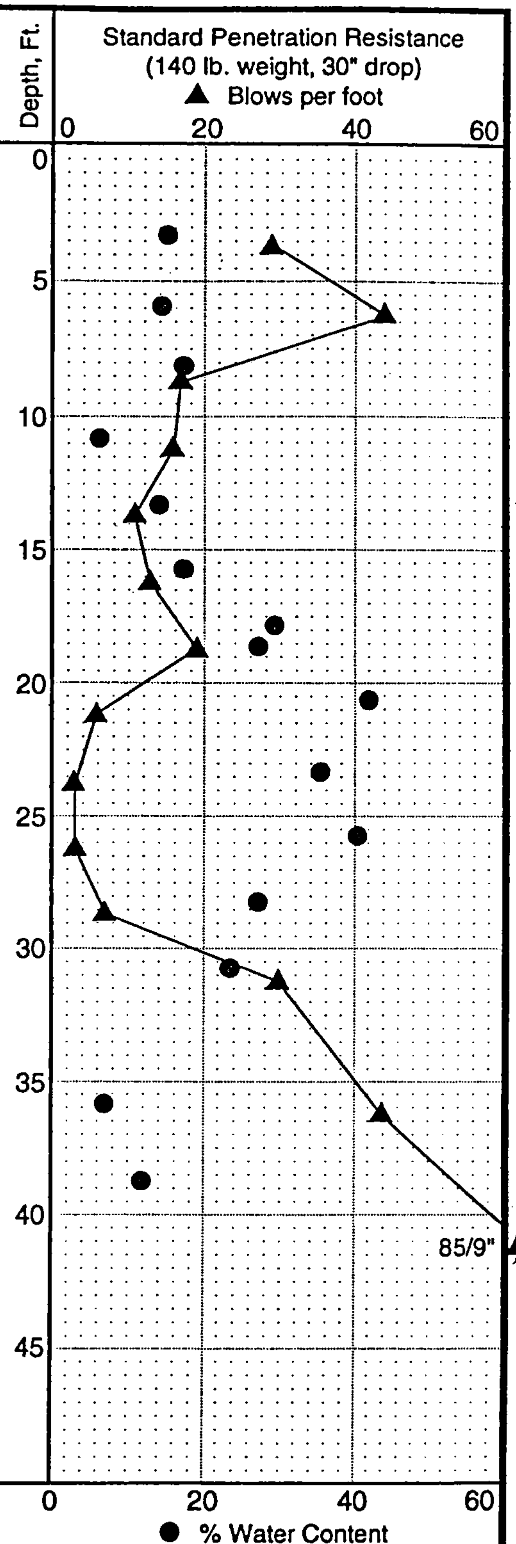
July 2000 21-1-08965-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7

MASTER_LOG 21-08965.GPJ SHAN_WIL.GDT 5/13/10 Log: LEE Rev: Typ: PEC

SOIL DESCRIPTION Surface Elevation: Approx. 55 Feet	Depth, Ft.	Samples	Ground Water
Medium dense (dense between 4 and 6.5 feet), gray to grayish brown, clean to silty, fine SAND; scattered fine gravel above 9 feet; trace oxide stains between 7.5 and 11.5 feet; scattered wood at 5 feet; moist to wet below 12.5 feet (FILL)	0	1, 2, 3, 4, 5, 6, 7	
Soft to medium stiff, gray to bluish gray, clayey SILT and silty CLAY; abundant organics in top 6"; trace fine sand; moist to wet	21	8, 9, 10	During Drilling ▽
Loose, gray, silty, fine SAND; occasional laminations of clayey silt; moist to slightly wet	27.5	11	
Medium dense, gray, clean to slightly silty, fine to medium SAND; wet	30	12	
Dense to very dense, gray and brownish gray, clean(?), gravelly SAND and sandy GRAVEL; wet	35	13, 14	
BOTTOM OF BORING COMPLETED 7-14-92	39.5		



LEGEND

- 2" O.D. split spoon sample
- 3" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:

- Liquid limit
- Natural water content
- Plastic limit

The stratification lines represent the approx. boundaries between soil types, and the transition may be gradual.

Monroe Sewage Treatment Plant Expansion
Monroe, Washington

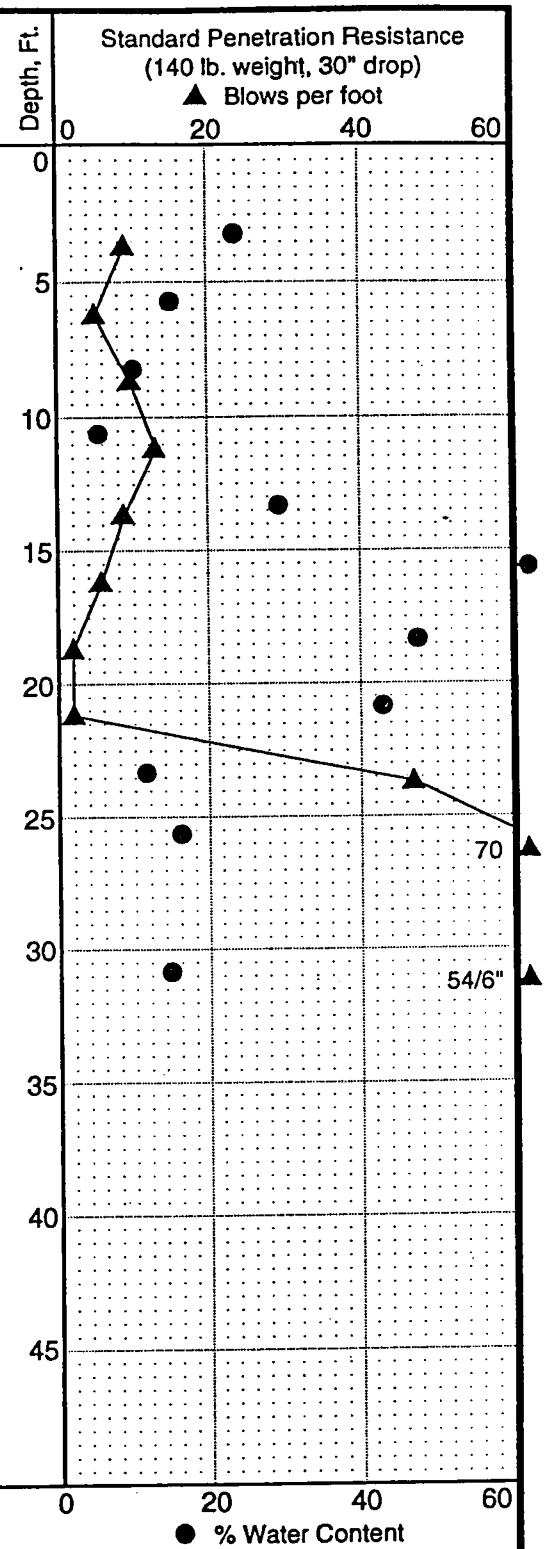
LOG OF BORING B-1

July 1992 W-6147-02

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8

SOIL DESCRIPTION Surface Elevation: Approx. 55 Feet	Depth, Ft.	Samples	Ground Water
Loose (medium dense between 10 and 11.5 feet), gray to grayish brown, silty, fine SAND; moist to wet below 12.5 feet (FILL)		1, 2, 3, 4, 5	
Soft to medium stiff, gray, clayey SILT and silty CLAY; scattered organics, trace fine sand; moist to wet	14	6, 7, 8	
Dense to very dense, gray, clean, gravelly, fine to coarse SAND; wet	23	9, 10, 11	During Drilling ▽
BOTTOM OF BORING COMPLETED 7-14-92	31.5		



LEGEND

- 2" O.D. split spoon sample
- 3" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- ▽ Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:

- Liquid limit
- Natural water content
- Plastic limit

The stratification lines represent the approx. boundaries between soil types, and the transition may be gradual.

Monroe Sewage Treatment Plant Expansion
Monroe, Washington

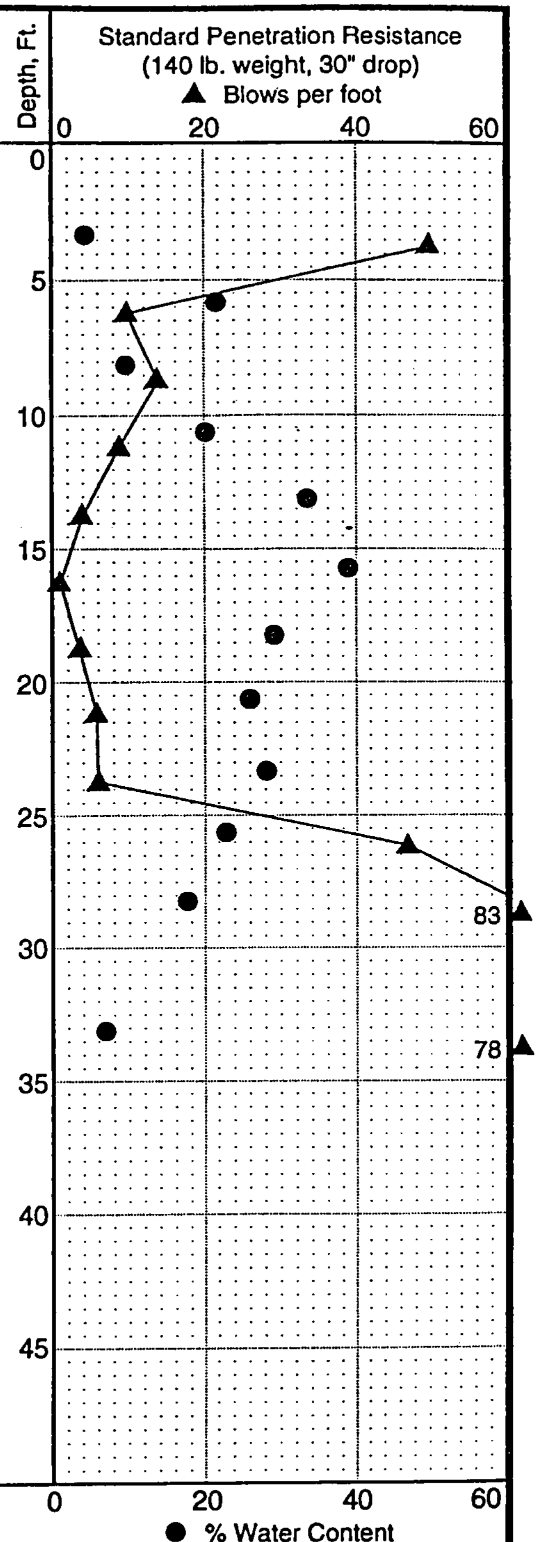
LOG OF BORING B-2

July 1992 W-6147-02

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9

SOIL DESCRIPTION Surface Elevation: Approx. 55 Feet	Depth, Ft.	Samples	Ground Water
Medium dense to dense, gray and brown, silty, fine SAND; scattered fine gravel, trace organics; moist (FILL)		1, 2, 3	
Very loose to loose, gray, silty, fine SAND; trace organics, occasional interbeds of clayey silt; oxide stains between 17.5 and 19 feet; moist to wet below 12.5 feet (FILL)	10	4, 5, 6, 7, 8	
Soft to medium stiff, gray, clayey SILT, scattered organics near 25 feet; moist	23	9	During Drilling
Dense to very dense, gray, clean, gravelly, fine to coarse SAND; wet	25	10, 11, 12	
BOTTOM OF BORING COMPLETED 7-14-92	34		



LEGEND

- 2" O.D. split spoon sample
- 3" O.D. thin-wall sample
- * Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:

- Liquid limit
- Natural water content
- Plastic limit

The stratification lines represent the approx. boundaries between soil types, and the transition may be gradual.

Monroe Sewage Treatment Plant Expansion
Monroe, Washington

LOG OF BORING B-3

July 1992 W-6147-02

SHANNON & WILSON, INC.
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FIG. A-10